IOP Conf. Series: Materials Science and Engineering **366** (2018) 012007 doi:10.1088/1757-899X/366/1/012007

Brief Discussion on the Design of Decision Support System for Flood Control Operation in Yangtze River

YU Shan* and LI Xiaonan

Changjiang Survey, Planning, Design and Research CO., LTD , Wuhan 430010, China

*yushan@cjwsjy.com.cn

Abstract. Flood control operation is the top priority for the management of the Yangtze River. To improve the timeliness and reliability of operation decision, it is of great significance to establish a set of intelligent decision system for flood control management, which can serve multi-level users. In order to achieve the goal, the key is to modularize the core business functions through the construction of topology relations of river network and control sites for the Yangtze River. In this paper, it would integrate the functions of hydrological forecast, flood propagation, flood control operation and flood risk analysis for the core business. Based on the core business model and information expansion interface, we develop flood control decision support system of the Yangtze River by virtue of GIS visualization and interactive WebService technology. The system can realize the real-time query of water-rainfall information and the fast-time simulation of flood control scheduling scheme, so as to provide the professional, scientific and accurate technical support for the group decision in the flood control.

1. Introduction

Flood control is of extreme significance in maintaining the stability of the Yangtze River. However, remarkable changes in hydrological features, as well as immediate pressure from socio-economic development in the catchment of the Yangtze River, pose great challenges for the river training. Especially, the situation of river training is becoming more and more complex, and training task is becoming more difficult as well as training requirements are getting higher and higher. Thus it calls for the hydraulic informatization to reinforce and become an crucial tool in the river training, which is also an essential condition for water conservancy modernization[1]. With the improvement of water conservancy modernization and development of hydraulic informatization, the rapid, real-time, accurate, automatic and intelligent processing in the flood control, to improve the flood control efficiency and accuracy, is the key to enhance flood control and management ability[2]. Moreover, it is also an important issue in the construction of flood control informatization.

In the flood control work, establishing a complete flood control decision-making support technology is necessary for flood prediction, which collects the relevant information quickly and automatically. With the real-time analysis and prediction of flood process, it can provide fast and effective technical support for management decision according to the requirements in the reservoir scheduling schemes[3,4]. This paper discusses the design of decision support system for flood control operation of the Yangtze River Basin from the aspects of the principles, ideas, system framework and system integration.

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

2. System design principles

The overall objective of decision support system for flood control dispatching is to provide decision support for correctly analysing and judging flood control situation and scientifically formulating flood control dispatching scheme[5]. At the same time, with the modern information technology, in order to strengthen the scientific nature of flood control command, improve the quickness, real-time and accuracy for information acquisition, transmission, processing and flood control scheduling decision-making, non-engineering measures are increasingly becoming an important means of flood control. Therefore, the following principles should be referred to in the design of flood control dispatching system.

2.1. Rapidity

In the decision-making process of flood control and dispatching, it is necessary to provide a scientific and reasonable scheduling scheme for the decision maker through the repeated interaction between the decision maker or the analyst and the computer system. Therefore, flood control software system should be able to improvise together with the computer rapid and accurate calculation, ordered logic judgment, high speed and high capacity data storage capacity and a series of algorithms, tools and people's creativity, providing convenient and fast operating environment for scheduling decision makers or business personnel.

2.2. Real-time performance

The occurrence of flood disaster usually has obvious diachronic process, and it is necessary to monitor the relevant information in real time from the initial state to the dangerous situation and the disaster situation. In order to ensure the scientific and effective command and decision-making, all kinds of flood control information need to be monitored in real time, such as warning, emergency response, command, dispatch, emergency rescue and disaster relief. Therefore, the flood control dispatching system should have strong actual combat and high real-time requirement.

2.3. Accuracy

According to the analysis of the business process in flood control work, combined with the actual conditions of the application requirements, the flood control dispatching system should combine with the principle of accuracy, to ensure the correctness and safety of the dispatching, and reduce the risk caused by the inaccurate scheduling scheme. On the premise of satisfying the accuracy, the performance of the scheduling model is optimized and the operation speed of the model can be improved. Correspondingly, the accuracy of flood dispatching is ensured.

2.4. Simulation

The occurrence, development and influence of flood disaster are generally distributed in space. Meanwhile the rapid response, such as command, dispatch, emergency rescue and disaster relief, is usually carried out in a certain space. Therefore, the spatial characteristics are important aspects of flood control work. To evidently demonstrate the spatial distribution, the emergency command and dispatch level will be greatly improved when three dimensional simulation is involved in flood control decision support. Using geographic information and 3D visualization technology to simulate reservoir scheduling, downstream channel flood evolution and inundation effect after the dispatching decision could be simulated vividly for decision-makers, thus help to make a scientific decision, and minimize flood damage.

2.5. Technical

Professional functions such as information query, forecast, scheduling calculation and scheme comparison, flood risk assessment, etc., can provide technical guarantee for the fast and accurate

simulation and calculation. Additionally, it can pave the way for the easy man-machine interaction and multi-objective, multi-project convenient analysis and comparison.

2.6. Persistence

In the design and implementation of flood control system, to follow the existing flood control business, it is envisioned to give full consideration to the next period of flood control requirements. The practical and mature technology is adopted to make the developed flood control dispatching system, which has favourable practicability and long life cycle. The system should be more open and expansible, so that the system can be updated, function upgraded, and the scheduling scheme can be extended in the future.

2.7. Friendliness

Flood control dispatching system is a man-machine interactive system, and the process of supporting flood control decision must be realized through the interaction between the decision-maker and the computer system. The system should provide a friendly man-machine interface with clear layers, flexible input and convenient operation. The decision makers can input operation instructions at any time to control the model calculation. System interface design as far as possible to provide function "navigation" or "one button" service, to improve the user experience, simplify the interface, and benefit the users.

3. System design ideas

The design and implementation of the flood control decision support system for the Yangtze River Basin should be based on the requirements of the flood control business application in the Yangtze River Basin[6]. According to the on-going trend of the information technology and the software engineering method, the design and implementation should be carried out under the norms and guidance of the unified technical framework.

The system design is based on evolution, forecasting, scheduling, risk analysis focusing on integration, to optimize the allocation of resources and information interoperability. Aimed at intelligent functional design, it should adapt to the generation of flood control scheduling scheme scientifically and fast. Besides, in order to take real-time flood control as the core, it should analyzes the different characteristics of the region and consider the requirement of real-time computing, with the construction of professional computing model. The three- dimensional simulation is used to realize the spatial scene display of the scheduling results, and show the regional flood control situation, scheduling simulation and flood loss assessment in a vivid way.

The system should be developed based on GIS technology, professional business model and business support platform technology, which provides fast analysis and judgment of the situation of flood control. Meanwhile it should provide various hydrology and hydrodynamics flood model in the computing service, to provide flood control, scheduling scheme optimization, flood simulation visualization and results management services for user. To Achieve the combination scheduling and single node scheduling of reservoir and river channel, manual scheduling node by node, a variety of scheduling results could be compared and analysed for better one, and carry out comprehensive management of flood forecasting and dispatching results. When floods occur, it can quickly collect and transport of water-rainfall regime, the labor, drought disaster information, and make a prediction about the trend and forecast, flood control scheduling scheme being put forward by the analysis. This scheme is the key to minimize disaster losses, to provide technical support for flood control decision-making. The system requires large amount of data, large amount of calculation analysis and short response time, that business flow and data flow should be analysed with solution.

4. Framework design of flood control dispatching system

The framework of flood control dispatching system is divided into six levels: infrastructure layer, data resource layer, business support layer, basic model layer, business application layer and function display layer [7].

4.1. Infrastructure layer

This layer is the material base of each business subsystem, including network environment, hardware server, storage device, security equipment, etc.

4.2. Data resource layer

The data resource layer includes the public data, special social and economic topics, water conservancy project, real-time hydrological information, thematic information, calculation model of flood characteristic information, flood damage information, flood control command reference information, spatial information, 3-D model information and so on. All kinds of data enter the corresponding subject database through ETL method, respectively. The data model and database application in flood control is created, via various views of application theme above the data model, to meet the demand of all kinds of data in the flood control system processing and information platform publication.

4.3. Business support layer

This layer provides unified technical framework and operating environment for flood control dispatching system. Meanwhile it provides universal application service and integrated service for system construction, as well as operation platform for resource integration and information sharing. According to the needs of the business, the flood control system calls for the business support platform file services, computing services, general data services, video services, access services, search / reporting services, real-time data and KPI services, map services, integrated services, mobile portal service, interface service, model service, database service, log service, distributed real-time computing services, batch computing services, to achieve the functional modules of comprehensive inquiry, water situation forecasting, flood control situation analysis, flood control dispatching, comprehensive analysis of decision making, achievement display and application, mobile terminal application, etc.

4.4. Basic model layer

Flood control system is designed for real-time flood control management capabilities to provide scheduling scheme generation, scheduling scheme simulation and effect analysis in one system, so that the system must be equipped with the corresponding calculation model, mainly includes confluence model, flood evolution model and cascade reservoir group scheduling model, etc.

4.5. Business application layer

According to the analysis of flood control and the business process, the design of business application layer covers the forecast, flood routing, river basin flood control situation analysis, flood control scheduling plan, proposed scheduling for flood control effect analysis, the proposed scheduling for flood risk assessment, flood control scheduling scheme generation module, the module support each other, complement each other, completed in flood control and the management of the business, as shown in figure 1.

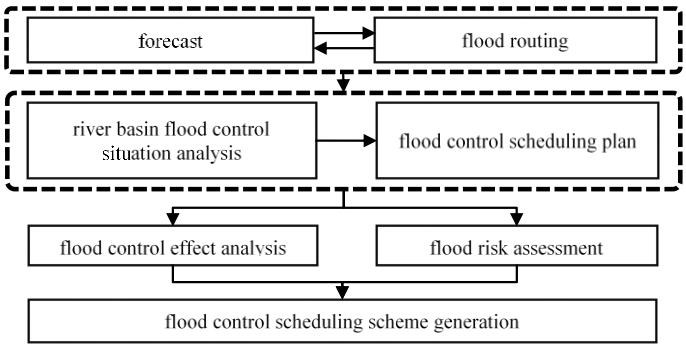

Figure 1. Service application layer module

4.6. Function display layer

On the basis of in-depth analysis of flood control and business requirements, the model based on professional technology integrates the use of online transaction processing technology, component technology, geographic information system (GIS), decision support system (DSS) and other high and new technology. Through the combination of flood control and special business, we can construct the advanced, scientific, efficient and practical flood control scheduling system, the flood control scheduling management and consultation with the daily work of operation interface and its function display module.

5. Organic integration of the whole system

Flood control operation system is composed of various business data, different business functions, business model and structure of the interface. To establish the system, it is necessary to integrate these modules into an organic wholeness. According to this idea, the option interface design for the flood control decision support system of Yangtze River basin (FCDSS-YR) is demonstrated in figure 2-3.

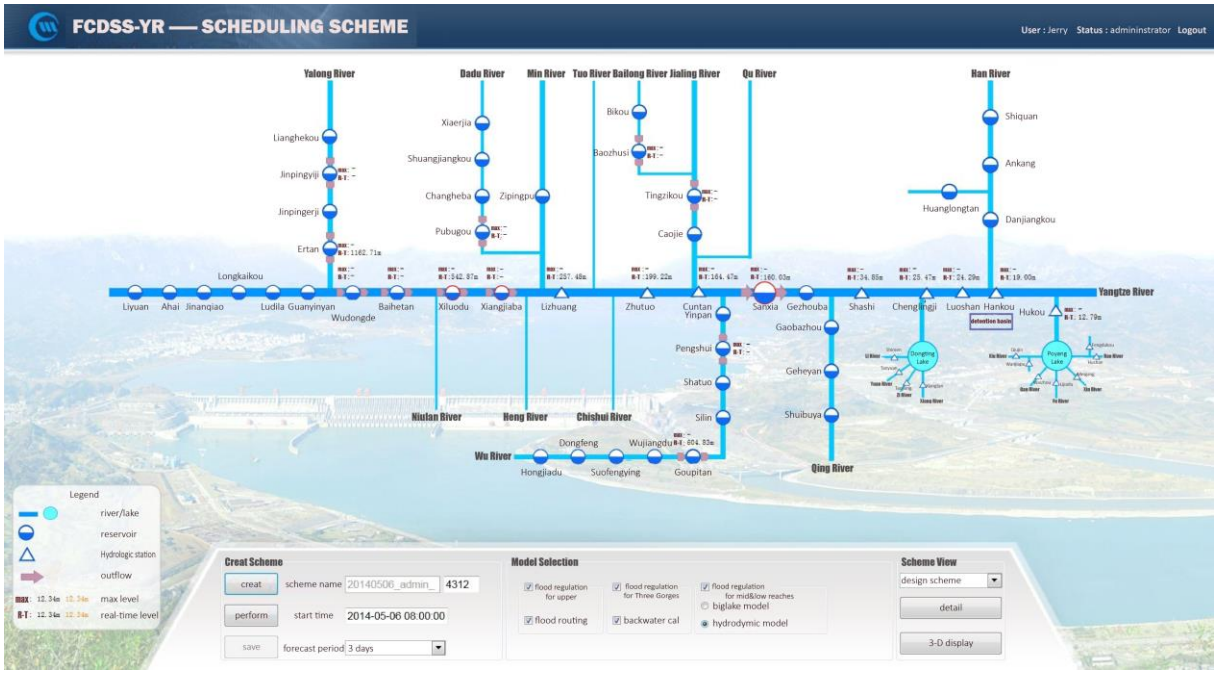

Figure 2. Interface of dispatching calculation in the FCDSS-YR

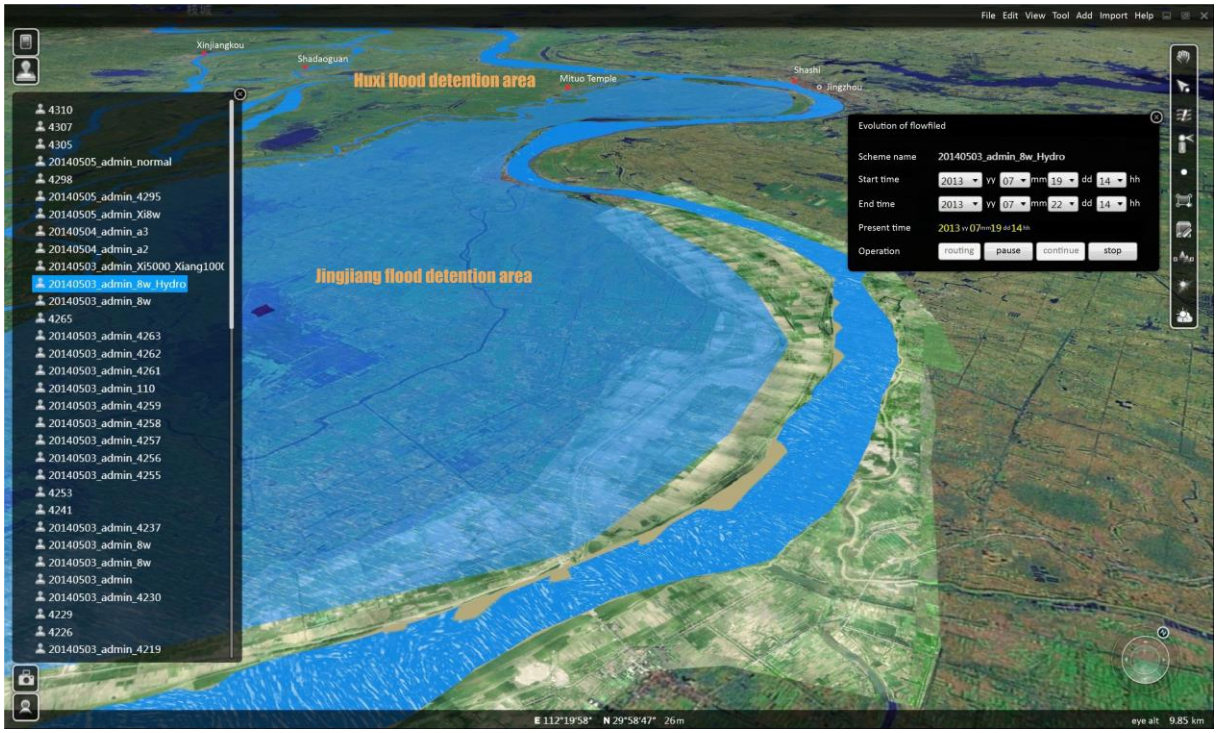

Figure 3. 3-D display interface of submergence in the FC-YR

In FCDSS-YR, it has implemented the integration of data, function, model and interface, which will be gone into details one by one.

For the data integration, it is essential to solve the problem of data sharing to make the data widely used in the system. Meanwhile, it contains multi-type data in the flood control system, such as water-rainfall data, hydraulic engineering data and model calculation data. Since these data source may be heterogeneous and be distributed in different regions, it is necessary to collect and integrate the multi-source data; and then converge to information data center through the joint transformation and copying technology.

As to the function integration, this system attempts to integrate the functions of hydrological forecast, flood propagation, flood control operation, flood risk analysis, information query and other business functions through the SOA based ESB (Enterprise Service Bus) technology. For the common functions of flood control system, such as information query, model calculation and file service, they can be provided by the enterprise service bus. Especially, the query of result can be fed back to the business function module for further calculation, analysis and display through the bus service.

As to the model integration, kinds of models such as hydrological forecast model, flood regulation model, calculation of backwater model, flood propagation model of downstream, risk assessment model are in modularity to realize above functions. It is worthy to point that these models are conjunctly integrated into the business support platform, which provides a unified computing service.

For the integrated interface, although the interface of each function module in the flood control scheduling system is not the same, we keep the unified style in the interface design. Meanwhile, the universal UI is addressed for different module function, such as user login interface, report export, authority management, information query interface and so on. Moreover, these interfaces are wholly integrated to business support platform.

The completion of FCDSS-YR can facilitate to comprehensively master the water-rainfall information and engineering disaster. What's more, it can accurately calculate the rainstorm and flood forecasting, quickly make various feasible dispatching solutions, and evaluate the scheduling schemes overall. With the aid of the FCDSS-YR, the group decision can achieve the scientific operation schemes as far as possible. Therefore, it can not only ensure the safety of flood control projects and the

minimum loss of flood disaster, but also can give full play to the effect of flood control engineering, so as to improve the flood control capacity for the crucial area and cities in the Yangtze River.

6. Conclusion

The flood control operation of the Yangtze River Basin involves the livelihoods of the people on both sides of the river, and it is of great significance to decide whether the dispatching is correct or not. The design of flood control system integrates the functions of hydrological forecasting, flood routing and control, flood risk analysis. It can strengthen the interaction and share massive information resources, improve the flood control decision support technology process, enrich the simulation of flood control operation and the expression means, as well as to improve the speed of decision-making, the level and quality to a new the level. Besides, the system can effectively improve the regional flood risk analysis and flood control ability for the key area in the Yangtze River Basin through the flood emergency transfer capability of three-dimensional display and flood. With the aid of the system, the flood control and disaster reduction of decision for administrative leadership to provide visual display has enhanced flood control and management of the Yangtze River basin level, while the efficiency and quality of the flood control work has been greatly improved. Overall, it will greatly reduce the economic loss, enhance the guarantee of sustainable economic-social development, and protect the people's lives and social stability.

Acknowledgments

This work is supported by the National Key Research and Development Program of China (Item Nos. 2016YFC0402207). The authors also appreciate the insightful comments and suggestions from anonymous reviewers.

References

[1] LIU H, LIU Y, XiONG Z, et al. Study and application of urban flood risk map information management system based on SOA[J]. Journal of Software, 2015, 10(2): 180-190.
[2] Ahmad S, Simonovic S P. An intelligent decision support system for management of floods[J]. Water Resources Management, 2006, 20(3): 391-410.
[3] Ahmad S, Simonovic S P. System dynamics modeling of reservoir operations for flood management[J]. Journal of Computing in Civil Engineering, 2000, 14(3): 190-198.
[4] Choudhury P. Reservoir flood control operation model incorporating multiple uncontrolled water flows[J]. Lakes & Reservoirs: Research & Management, 2010, 15(2): 153-163.
[5] LI Anqiang, ZHANG Jianyun, ZHONG Zhiyu, etc. Study on joint flood control operation for leading reservoirs in the upper Changjiang River [J]. Journal of Hydraulic Engineering, 2013, 44(1):59-66. (in Chinese)
[6] LI Shufei, CHEN Shuli, HE Xiaocong. Key Technologies in United Flood Control Operation System of Lower Jinsha Cascade Reservoirs and Three Gorges Project[J]. Hydropower and New Energy, 2014(2):1-5. (in Chinese)
[7] YU Shan, LUO Bin, ZHANG Hengfei. Design of decision support system for flood control operation in Yangtze River Basin [J]. Yangtze River, 2015, 46(21):5-7. (in Chinese)